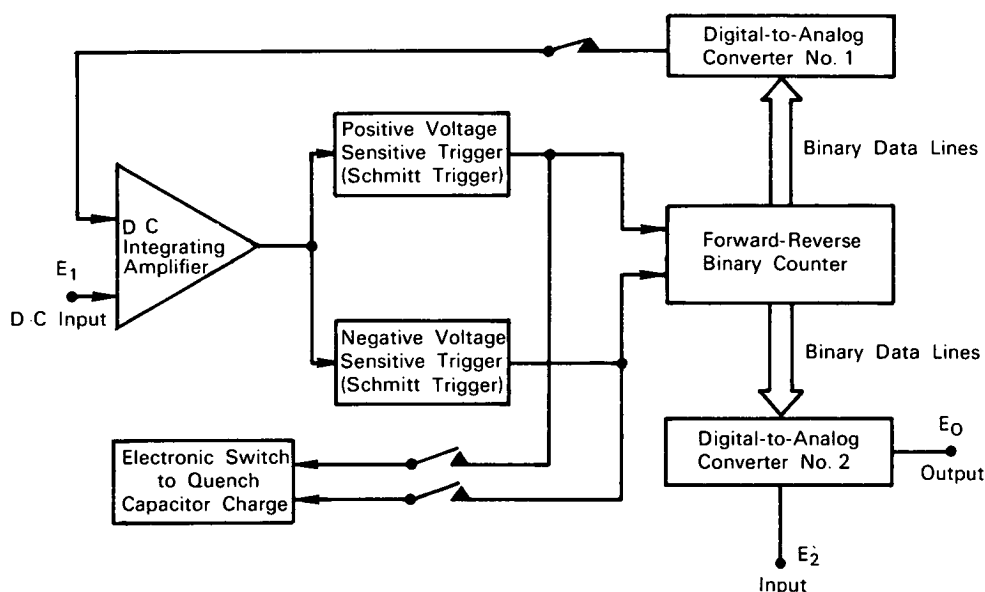


# NASA TECH BRIEF



This NASA Tech Brief is issued by the Technology Utilization Division to acquaint industry with the technical content of an innovation derived from the NASA space program.

## Digital Logic Elements Provide Additional Functions from Analog Input



**The problem:** To develop a system that can use a d.c. analog input to produce an integrator with high dynamic range or a d.c. position servo with good inherent stability.

**The solution:** A system in which appropriate switching utilizes digital-to-analog converters and an electronic switch to provide the desired outputs.

**How it's done:** With digital-to-analog converter No. 1 in the system and the electronic switch disconnected, the system can be made to function as a d.c. position servo. Feedback of the output voltage of converter No. 1 will tend to cancel the input control voltage at the integrating amplifier summing point. With the d.c. input to the amplifier at other than zero, the integrating capacitor will charge either positive or negative. When the trigger voltage is reached,

the counter will count up or down depending on the polarity of the charge. As the counter changes its register, the output of converter No. 1 will also charge a value corresponding to one least-significant bit. Thus the difference input at the amplifier summing point is reduced by this amount. As the point is approached where the input and feedback voltages are equal, the charging action will slow almost to a stop. The output from converter No. 1, changing in steps, will never produce an exact null condition and the charge on the capacitor will oscillate around the true null state, thus eliminating drift, an inherent problem in conventional analog equipment.

With converter No. 1 feedback circuit open and the electronic switch connected, the system can be used as an integrator with a dynamic range of 4,000 to 1.

(continued overleaf)

When a d.c. input is applied at  $E_1$ , the amplifier integrating capacitor charges at a rate proportional to the applied voltage. When a specific voltage level is reached, the appropriate voltage-sensitive trigger produces an output that steps the forward-reverse binary counter and simultaneously causes the electronic switch to quench the charge on the integrating capacitor. This action is repeated as long as an input is applied at  $E_1$  and converter No. 2 registers the value of the time-integrated voltage. With some functional voltage input applied at  $E_2$ , the output at  $E_0$  will be the product of  $E_2$  and the time-integrated voltage at  $E_1$ . In this system, if the counter is capable of registering 1,023 bits, the overall accuracy of the system approaches 0.1 percent. Larger registers would afford even greater accuracy.

**Notes:**

1. In the latter configuration, the system could be used as a multiplier in an analog computer, al-

though response time utilizing the present integrating capacitor circuit is relatively slow, being in the vicinity of 1 second. Response time of one millisecond may be possible using solid state circuitry.

2. For further information about this innovation inquiries may be directed to:

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Houston, Texas 77001  
Reference: B64-10064

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA Headquarters, Washington, D.C. 20546.

Source: McDonnell Aircraft Corporation  
under contract to  
Manned Spacecraft Center (MSC-64)